Nanofibre optic force transducers with sub-piconewton resolution via near-field plasmon-dielectric interactions.

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Public Summary:
We developed a novel force sensing platform that leverages the optical response of plasmonic nanoparticles attached to a compressible cladding embedded in the evanescent field of a nanofibre. We achieved ångström-level distance sensitivity and a force sensitivity of 160 fN. After fully calibrating the system, the sensing platform was used to detect sub-piconewton forces from the swimming action of bacteria, and acoustic signatures from beating cardiomyocytes with a sensitivity of −30 dB. With the ability to tune the force and dynamic range via the mechanical response of the compressible cladding, detect forces from multiple nanoparticles on a single fibre, and with a geometry that can be inserted into small volumes, this sensing platform will become a valuable tool for biomechanical and intracellular studies.

Scientific Abstract:
Ultrasensitive nanomechanical instruments, including the atomic force microscope (AFM)(1-4) and optical and magnetic tweezers(5-8), have helped shed new light on the complex mechanical environments of biological processes. However, it is difficult to scale down the size of these instruments due to their feedback mechanisms(9), which, if overcome, would enable high-density nanomechanical probing inside materials. A variety of molecular force probes including mechanophores(10), quantum dots(11), fluorescent pairs(12,13) and molecular rotors(14-16) have been designed to measure intracellular stresses; however, fluorescence-based techniques can have short operating times due to photo-instability and it is still challenging to quantify the forces with high spatial and mechanical resolution. Here, we develop a compact nanofibre optic force transducer (NOFT) that utilizes strong near-field plasmon-dielectric interactions to measure local forces with a sensitivity of <200 fN. The NOFT system is tested by monitoring bacterial motion and heart-cell beating as well as detecting infrasound power in solution.